B1 cont.

comprises the step of achieving maximum continuous wave laser output operation of the semiconductor laser diode slightly above the lasing threshold input current.

–REMARKS–

The Examiner has rejected claims 1-10, 12, 13, 15, and 16 as being unpatentable over US patent no. 4,405,236 by Mitsuhashi et al. in view of a publication by Spence et al. entitled "60-fsec pulse generation from a self-mode-locked Ti:sapphire laser".

The Examiner has stated that claims 11, 14, 17 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Claim 8 has been amended for clarity.

Mitsuhashi et al. describes a semiconductor ring laser apparatus which comprises a semiconductor laser element having a waveguide region therein and parallel cleavage planes formed between the waveguide region and the medium adjacent thereto. The system uses the principle of a Brewster angle to create a condition wherein a linear polarized wave, of which an electric field vector is in parallel to the plane of incidence, is completely non-reflected on the cleavage plane. Additionally, a ring-formed optical path is provided outside the element so as to effect a ring laser oscillator.

Spence et al. describes a self-mode-locked Ti:Al_2O_3 laser that is capable of producing pulses with durations as short as 2.0 psec. Intracavity dispersion compensation is used in a mode-locked Ti:Al_2O_3 laser to produce pulse durations as short as 60 fsec and peak powers of 90 kW. By using an extracavity fiber-prism compressor and utilizing high-dispersion ZnSe prisms, pulses as short as 45 fsec are produced.

Applicants claim a method of generating laser pulses using a semiconductor laser diode as a lasing amplification medium of an extended laser cavity. The elements making up the laser cavity are aligned for maximum laser output. The semiconductor laser diode is provided with an input current beyond a lasing threshold and at least one

of the elements making the laser cavity is misaligned to achieve passive mode-locked operation of the semiconductor diode.

In Mitsuhashi et al, although elements are aligned to provide a semiconductor ring laser apparatus (figure 4), there is no suggestion that an input current *beyond a lasing threshold* is provided to the semiconductor laser diode. The semiconductor element 11 is driven via an electric source 13 through a resistance 12. The level of the input current is not discussed. Applicants clearly state on page 10, line 13 that "typically, I is set to $1.2I_{th}$". Furthermore, the ring laser oscillator disclosed in Mitsuhashi et al. does not operate in a passive mode-locked state. It is not an object of Mitsuhashi to achieve mode-locked operation. The ring laser apparatus described by Mitsuhashi is clearly a typical ring laser oscillator based on the Brewster angle principle and has the object of providing a semiconductor ring laser apparatus which is suitable for use in a ring laser gyroscope apparatus. Therefore, misaligning at least one of the elements making the laser cavity to achieve passive mode-locked operation of the semiconductor laser diode is not considered, discussed, or even desirable.

Mitsuhashi et al. operates with the semiconductor laser element having facets inclined at the Brewster angle. The laser taught by Mitsuhashi et al. would not be operational for its intended purpose if altered from the Brewster angle inclination. In Applicants' invention, the inclined facets are not at the Brewster angle.

There are several methods used to obtain mode-locking. Applicants describe active, passive, and hybrid methods in the background of the invention. Typically, passive mode-locking is achieved using saturable absorbers. "A saturable absorber has a property that its transmission is controlled by an incident laser beam. Due to the dynamics of the energy levels involved in the absorption process, transmission increases as the laser signal intensity increases. As a result, the peak of a pulse propagating therethrough undergoes a smaller absorption than the wings. The net effect is that the transmitted pulse is shortened with respect to the incident pulse. Furthermore saturable absorbers tend to quench weak signals. Hence saturable absorbers provide a mechanism of self-modulation of the laser signal. When inserted in a laser cavity, saturable absorbers tend to restrict laser emission to short pulses. The technique is said to be passive since no external electrical or optical signal is necessary to produce the modulation." (page 3, line 24 – page 4, line 7). These

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methods of mode-locking are used for guided wave structures such as semiconductor lasers.

Spence describes achieving self-mode locking using solid state lasers. "Solid-state lasers, such as color center and titanium-sapphire lasers, have been mode-locked through a variety of techniques that involve nonlinear phase modulation (self-phase modulation, self-focusing)." (page 6, lines 10–12). "In solid-state lasers the most efficient method of generating trains of short pulses is Kerr-lens mode-locking as described by D.E. Spence et. al. in the above mentioned publication. This method provides short stable and controllable pulses having a fast repetition rate and high peak power. Kerr-lens mode-locking relies upon self-focusing, e.g. on a lensing effect produced by the laser pulse itself when it propagates through the gain medium. Kerr-lens mode-locking takes place only when the cavity geometry is set such that non-linear lensing improves round-trip laser gain or decreases round-trip losses." (page 6, line 26 – page 7, line 4).

Spence et al. teach (at page 43, first column, first paragraph) that the power from their laser dropped by roughly 40% after the cavity realignment that led to mode-locked operation. Spence et al. also mention in the same paragraph that there is significant change in beam shape after the cavity realignment that produced mode locking. These characteristics are undesirable. In Applicants' invention, no such negative effects were observed. In fact, the power from one beam (Clockwise Beam) increased when mode locking was produced following cavity realignment, and the power from that beam increased by a factor of 3-4.

There is a significant difference between solid state lasers and guided-wave structures such as semiconductor lasers. Applicants describe this on page 7, lines 5-9: "In guided-wave structures such as semiconductor laser diodes, self-focusing is not effective as a mode-locking mechanism since it represents only a weak effect in comparison with the guiding effect produced by the guided-wave structure itself. This is probably why passive self-modulation mode-locking based upon self-focusing is not operational in semiconductor laser diodes.". "To date, only one method relying on nonlinear phase modulation has been successfully tested with semiconductor laser diodes: coupled-cavity mode-locking." (page 6, lines 17 – 19).

It is for these reasons that it is not obvious to combine the methods described in Spence with the ring laser apparatus in Mitsuhashi. The techniques used by Spence are specifically for solid state lasers and in the past, have proved ineffective for guided-wave structures. The results obtained by the Applicants are unexpected results. Applicants strongly believe independent claim 1 to be non-obvious with respect to the cited references.

Claims 2-17 are all dependent on independent claim 1. In view of the arguments stated above, Applicants consider these claims to be dependent on a valid claim and therefore patentable over the state of the art.

In view of the foregoing, reconsideration of the rejection of claims 1-17 is respectfully requested. It is believed that claims 1-17 are allowable over the prior art, and a Notice of Allowance is earnestly solicited.

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CERTIFICATE OF FACSIMILE TRANSMISSION

I hereby certify that this paper is being facsimile transmitted to the Patent and Trademark Office on the date shown below.

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Name of person signing certification

Signature

June 28, 2002

Date

Marked-up copy of claims

8.(amended) A method as claimed in claim **Error! Reference source not found.**, wherein the elements making up the laser cavity are optical elements and the step of aligning the optical elements of the laser cavity for maximum laser output further comprises the step of achieving maximum continuous wave laser output operation of the semiconductor laser diode slightly above the lasing threshold ~~at the lasing threshold~~ input current.